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PRINCIPAL INVESTIGATOR: Felicia Cosman, M.D.

CONTRACTING ORGANIZATION: Health Research, Incorporated
Rensselaer, New York 12144

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13. ABSTRACT *(Maximum 200 words)*

The determinants of peak bone mass and stress fracture risk are of both immediate and long-term interest to the military community. Research in these areas is being conducted on the class of 2002 over a four-year period at the United States Military Academy. In this study we have recruited 891 cadets (752 males and 139 females). The data collected to date include baseline historical information (including dietary calcium intake, menstrual function and past fracture history), baseline blood samples, baseline and year 1 bone densitometry , and interval surveys over the first year at USMA regarding physical activity, menstrual function and dietary habits as well as stress fracture occurrence. The bone densitometry tools used included peripheral Dual xray absorptiometry (Lunar PIXI) for heel measurements (n=880), peripheral Quantitative Computed Tomography (Norland pQCT) which measures total and cortical tibial bone density (n=7) and a mobile central dual xray absorptiometer (Lunar DPX-IQ) for bone density of the lumbar spine and hip (n=300). Calcaneal BMD was on average one standard deviation higher BMD in both male and female cadets then the age and gender matched general population. Determinants of heel BMD included normal menses in female and exercise levels and milk consumption in male cadets. Women had a higher incidence of stress fracture (12.2 % versus 3.5 % in males during 9 months at USMA). The etiology for stress fractures for males and females appeared to differ. In women with fractures, BMD at the heel, spine and hip were all lower than in women without fractures. In men, heel BMD did not discriminate cadets with fracture versus those without, however, cortical thickness of the tibia was a major predictor of stress fracture risk.

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FOREWORD

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____ In the conduct of research involving hazardous organisms, the investigator(s) adhered to the CDC-NIH Guide for Biosafety in Microbiological and Biomedical Laboratories.

[signature] 7/26/99
PI - Signature Date

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SECTION I - INTRODUCTION:

The study " The Determinants of Peak Bone Mass and Stress Fractures in Elite Military Cadets" was designed to examine four specific aims. They have been modified slightly because full funding for multiple phlebotomies was not granted. This will be annotated in the text of the specific aims.

(1) To determine the epidemiology of stress fractures in West Point Cadets during their four years at the Academy. To identify the relative importance of bone mass, quality and turnover, calcium intake and physical training in determining the risk of stress fractures.

(2) To examine the relationship of allelic variation in three separate genetic markers (Vitamin D Receptor, Type I Collagen and Estrogen receptor) to stress fractures and bone mass.

(3) To determine the incidence of menstrual irregularity and sex steroid production, in male in female cadets during intensive physical training. . Menstrual function in female cadets will be determined by questionnaire.

(4) To determine prospectively the relative importance of gonadal function, calcium intake and physical activity as determinants of bone turnover, mass and quality at multiple sites in male and female cadets. Calcium intake will still be assessed annually by web based food frequency questionnaire and physical activity will be assessed by online questionnaire and confirmed by collecting class registration and corps squad information from the academy. Menstrual function in female cadets will be determined by questionnaire.

SECTION II- BODY:

The determinants of peak bone mass and stress fractures are of both immediate and continuing interest to members of the military community. It is also of long-term general interest to the population at large since bone mineral density is related to the development of osteoporosis later in life. Research in these two main areas is being conducted on the class of 2002 over a 4-year period at the United States Military Academy. The data collection efforts directed at the specific aims of this study include a baseline phlebotomy and baseline lifestyle, medical and family history. These were collected during the cadets first week at the academy following informed consent. In addition, during Cadet Basic Training (CBT) in the summer of 1998, 3 different tools were used to assess various physiologic properties of the bone. The tools used for the bone densitiometry included 2 Lunar Pixi peripheral DXA machines (PIXI), 1 Norland peripheral XCT 2000 (pQCT) scanner and a mobile Lunar DPX-IQ (DXA). The Lunar Pixi machines were used to take a calcaneus bone density measurement. The Norland pXCT provided total, trabecular and cortical density for the tibia. The DPX-IQ was used to assess the bone mineral density of the hip, femoral neck, wards triangle, trochanter, and lumbar vertebrae L2-L4.

Prior to initiation of the study in June of 1998, each cadet of the incoming class of 2002 was mailed an overview and a consent form to review at home. (APPENDIX A) The Class of 2002 was briefed by company and then subsequently enrolled in the study. Table 1 provides participation rates.

TABLE 1- PARTICIPATION RATES

Cadet Basic Training Company	% Participation
A	76%
B	78%
C	75%
D	46%
E	71%
F	63%
G	75%
H	78%
OVERALL	70.25% (884)

There were initially 884 cadets in the study. 3 cadets withdrew from the study: 2 due to the online survey and 1 cadet withdrew because of the blood draw. 8 cadets consented in the field and 43 cadets are no longer enrolled as cadets in the Academy. The highest number of participants in the study at any time was 891. The racial and gender distributions for these 891 cadets are provided in Table 2. There were additional withdrawals from the academy during the recent months, 5 with drew from the study in the summer of 1999 and one was hospitalized so not available for measurement. As of July 10, 1999 there are 789 cadets in the study.

TABLE 2: RACE AND GENDER DISTRIBUTION

Gender	White	Hispanic	Black	Asian	Other	Total
Female	105	13	13	2	3	136
Male	631	37	62	2	12	744
Total	736	50	75	4	15	880*

These data were self reported and given to the Academy on admission forms. There are 11 cadets who did not report.

The actual results from data collection efforts are presented in tables 3, 4 and 5. The baseline phlebotomy and baseline lifestyle, medical and family history was only completed in the first year. All other measures were performed both years on all available cadets. In the second year, body composition was included since our initial findings determined that BMI was not a good indicator of fitness in this population.

Additional effort directed at the specific aims and monthly questionnaires were handled by establishing a study website. This website (http://sql3.pica.army.mil/CadetStudy/htm), which is password protected, has monthly questionnaires to assess menstrual function, physical activity and pain and an annual food frequency survey. The food frequency was changed from twice a year to once a year to increase cadet compliance. Samples of the online survey are provided in Appendix B, C and D.

TABLE 3. DATA COLLECTION RESULTS FOR 1998

Data Collection	n
Phlebotomy	866
PIXI	841
DXA	292
PQCT	768
Food Frequency Survey	454
Baseline Survey	851

TABLE 4- DATA COLLECTION RESULTS FROM THE SUMMER 1999

Data Collection	n
Body Composition	767
PIXI	786
DXA	261
PQCT	700
Food Frequency Survey	786

One of the primary outcomes of interest, stress fractures, is being continually assessed. The orthopedics department at USMA confirmed stress fracture diagnoses, on the basis of initial x-ray, follow up x-ray or bone scan results. The Class of 2002 had a total of 66 fractures in 51 cadets which occurred between initiation of cadet basic training and March 1,1999. Of those that consented to be in the study there were 51 fractures in 37 cadets. Table 5 provides a distribution of the site of fracture by gender.

TABLE 5. Fracture Sites of Consented Cadets

	Metatarsal	Tibia	Fibula	Femur	Total
Female	17	6	1	1	25
Male	23	2	1	0	26
Total	**40**	**8**	**2**	**1**	**51**

Note: There were 51 fractures among 37 cadets

In addition to the clinical data listed in tables 3, 4 and 5, nutritional information, swim test scores, and physical fitness test scores and sport specific information about each cadet (gathered from the academy) were also being collected. All these factors are being used as variables in the model examining those factors that are predictive of stress fractures and peak bone mass accrual.

SECTION 7- KEY RESEARCH ACCOMPLISHMENTS

- Established website to collect data, questionnaires and keep study participants informed
- Obtained initial phlebotomy on 866 cadets during their first week at the academy
- Calcaneus bone mineral density measurements were taken on 841 in the summer of 1998
- Calcaneus bone mineral density measurements were taken on 786 in the summer of 1998
- Collected and analyzed baseline information on 851 cadets.
- Performed 292 lumbar spine and femur during the summer of 1998 and 261 in 1999 using mobile Lunar DPX-IQ scanner
- Collected 700 measurements of trabecular and cortical density of the tibia using the Norland peripheral XCT 2000 scanner in the summer of 1998
- Collected 714 measurements of trabecular and cortical density of the tibia using the Norland peripheral XCT 2000 scanner in the summer of 1999.
- Collected comparison data from 2 other colleges.
- Analyzed baseline bone mineral density measurements at different sites
- Examined the relationship of BMI and BMD in cadets
- Size matched a sub-population to examine the differences in cortical thickness by gender
- Collected menstrual function questionnaires on the 118 women remaining at the academy who were in the study in the summer of 1999
- Collected food frequency questionnaires on all participants during the summer of 1999
- Presented findings to the United States Military Academy's Department of Physical Education on study progress
- Analyzed the stress fracture data and examined the etiology of stress fractures in each gender.

SECTION VIII- REPORTABLE OUTCOMES

- Oral Presentation--Formica, C.A., Nieves J, Shen V., Ruffing J., Lindsay R., Cosman F., Differential Effects of Gender on Bone Mass and Biomechanical Competency of the Axial and Peripheral Skeleton In Adolescent Elite Military Cadets. Oral Presentation at the First International Congress of Children and Bone Health, Maastricht, May 1999

- Poster Presentation -Ruffing, J. Nieves, J. Formica C. Lindsay, R. Cosman F, Correlation Between Body Mass Index and Bone Mineral Density with Standardized Fitness Test Scores in Elite Military Cadets. Poster Presentation at the Society for Epidemiologic Research, Baltimore Maryland, June 1999

- Plenary Poster Presentation – Cosman F, Ruffing, J., Nieves, J., Formica C. , Lindsay, R., Stress Fractures in Elite Military Cadets Selected for American Society of Bone Mineral Research St Louis Missouri Oct 1, 1999 -

SECTION IX- CONCLUSIONS

There was a maximum of 891 cadets enrolled in this study at its peak. At that time, the average age was 18.8 (range 16-23). The mean values for males were 24.7 ± 3.4 for BMI, BMD .72 ± .14 g/cm^{2} for BMD and 214 ± 33.8 for PT score. The mean values of BMI, BMD and PT for females were 23.1±2.3 kg/m^2 .59 ± .09 g/cm^2, and 206 ± 42 respectively. For all measurements the males' values were significantly higher then females values. Both genders had mean BMD values that were approximately one standard deviation above young normal according the data provided by the manufacturer of the peripheral DXA machine, Lunar Inc.[1]

There are a number of previously reported determinants of stress fractures and peak bone mass. The risk of stress fracture appears to be inversely proportional to age between 17 and 26 [2-4] and may be lower in blacks then in whites. Additionally, women have more stress fractures then men. In addition, low levels of fitness, in particular low scores in a standardized run test at entry are correlated with stress fractures.

Our data support these previously reported data. In addition, our examination of body composition through body mass index was not an indicator of fitness and therefore was not a determinant of fracture. It was, however, positively correlated with BMD. The military may, by examining entry standardized run scores, predict BMD. For example we found Pearson correlations between BMD and PT, BMI and Run Score were significant. The values were for BMD and BMI ($r = .48$; $p = .0001$), BMD and PT ($r = -. 1$; $p = .003$) BMD and Run Score ($r = -12$; $p = .0003$). When partial correlations between the three fitness variables and BMD were examined controlling for age, there was still a significant relationship between run score in males ($r =-. 20$; $p=. 0001$) but this was not significant in females. Standardized run scores can be predictive of enhanced BMD in men. The female athlete triad may ameliorate the positive effects associated with Run Score, BMI and BMD. In fit populations, including elite cadets, Lean Body Mass (LBM) might be a better indicator then BMI in predicting BMD.

We found the incidence rate of stress fractures during the first six months in female cadets was 12% (18% when counting multiple fractures) and in male cadets was 3.5% during their first academic year. The role of gender differences in bone mass and biomechanical properties of the skeleton on fracture incidence in both adolescents and adults is uncertain. Gender differences in fracture rates may be the consequence of differences in body and skeletal size, the geometric properties of the skeleton, and or, greater bone mass for equivalent habitus. In this study, we sought to determine the gender-related differences in bone mass, size, geometry and biomechanical competence in adolescent elite military cadets of similar size.

We examined the bone size (area), mass (g), bone density (g/cm2) of the lumbar spine and proximal femur were measured by dual x-ray absorptiometry using the (Lunar DPX-IQ). Distal tibia bone density (mg/cm3), cortical thickness and strength indices were determined by pQCT (Stratec XCT-2000). We observed no difference at the lumbar spine for vertebral bone mass, or area, with a trend towards greater areal density ($p < 0.06$) in the male cadets compared to female cadets. Despite similar vertebral height, the male cadets had greater vertebral width compared to the female cadets (4.50 ± 0.05 vs. 4.31 ± 0.05 cm, $p < 0.01$). No differences were observed for femoral neck areal density and total femur areal density. By contrast, male cadets had greater bone mass and bone area at both the femoral neck (6.2 ± 0.1 vs. 5.7 ± 0.1 g, and, 4.9 ± 0.1 vs. 4.7 ± 0.1 cm^2, respectively, $p < 0.02$ for both) and total femur (43.6 ± 1.0 vs. 38.0 ± 0.9 g, and, 34.4 ± 0.4 vs. 32.0 ± 0.4 cm^2, respectively, $p < 0.01$ for both) compared to female cadets.

Tibia length between male cadets and female cadets was not different. However, at the distal tibia, male cadets had greater tibial bone mass (333.3 ± 6.7 vs. 299.2 ± 6.2 mg/mm, $p < 0.01$), volumetric density (851.5 ± 14.2 vs. 804.9 ± 10.9 mg/cm^3, $p<0.02$) and cortical area (270.7 ± 5.7 vs.

238.6 ± 5.0 mm², p<0.01). Cortical thickness was also greater in the male cadets (5.0 ± 0.1 vs. 4.4 ± 0.1 mm, p<0.01). This was the result of greater periosteal circumference and smaller endosteal circumference in the male cadets compared to the female cadets. These structural differences resulted in 13% greater axial moment of inertia, 11% greater moment of resistance, and 13% greater polar moment of inertia, in male cadets compared to female cadets.

Despite comparable body size, male and female cadets still have differences in skeletal size. However, we conclude that gender differences in bone density are skeletal site dependent and that these differences in bone size and mass confer greater skeletal integrity in male cadets, which may contribute to the lower gender-specific stress fracture incidence, and possibly adult fracture incidence observed in adults.

We also examined lifestyle as a predictor of Bone Mineral Density in 848 of the cadets by using the baseline survey with questions relating to physical activity, calcium intake, alcohol intake, smoking history and personal and family fracture history during the year prior to entry in the academy. We found that male cadets who exercised more that 11 hours per week had significantly higher BMD (0.732 +/- 0.12) than male cadets who exercised less frequently (0.705 +/- .12 g/cm2 p<0.01) This relationship was not seen in women. Average daily dietary calcium intake was 1031 mg for males and 923mg for females. Male cadets with milk intake of 3 or more glasses per day (adequate calcium intake) hand higher BMD (0.70+/- 0.15) compared with lower intakes (0.72 +/- .12 g.cm^2; p<0.07). In female cadets milk consumption itself was not associated with BMD however, total dietary calcium intake was correlated with BMD (r=0.214; p <0.02). Neither alcohol intake nor smoking exhibited any apparent influence on BMD but in both cases there were few cadets who smoked (n=43) or drank more than 3 glasses of alcohol a week (n=27). Those women having fewer than 9 menstrual cycles the prior year had significantly lower BMD (0.554 +/- 0.09 g/cm^2; p<0.05) then those with normal cycles. BMD in active cadets is influenced predominantly by calcium and menstrual function in females and by exercise levels and milk intake in males.

The determinants of peak bone mass will be examined with the collection of second year BMD and stress fractures predictors will continue to be examined.

SECTION X- REFERENCES

[1] Lunar Reference Data, Lunar Inc. Madison WI 53713

[2] Milgrom C, Finstone A, Shlamkovitch N, Rand N, Lev B, Simkin Weiner M. Youth a risk factor stress fracture: a study of 783 infantry recruits. J Bone Joint Sur 76B; 20-22, 1994.

[3] Mori S, Burr DB, Increased intracortical remodeling following fatigue damage. Bone 14:103-109, 1993.

[4] Jones BH, Cowan DN, Tomlinson JP, Robinson JR, Polly DW, Frykman PN. Epidemiology of injuries associated with physical training among young men in the Army. Med Sci Sprt 15: 197-203, 1993

Reducing Stress Fractures in Physically Active Women, National Academy Press 1998

Army Regulation AR 350- 15 Army Physical Standards Headquarters US Army Washington DC

APPENDIX A

VOLUNTEER AGREEMENT AFFIDAVIT

For use of this form, see AR 70-25 or AR-40-38. The proponent agency is OTSG

PRIVACY ACT OF 1974

Authority: 10 USC 3013, 44 USC 3101, and 10 USC 1071-1087.

Principle Purpose: To document voluntary participation in the Clinical Investigation and Research Program. SSN and home address will be used for identification and locating purposes.

Routine Uses: The SSN and home address will be used for identification and locating purposes. Information derived from the study will be used to document the study, implementation of medical programs, adjudication of claims, and for the mandatory reporting of medical conditions as required by law. Information may be furnished to Federal, State and local agencies.

Disclosures: The furnishing of your SSN and home address is mandatory and necessary to provide identification and to contact you if future information indicates that your health may be adversely affected. Failure to provide the information may preclude your voluntary participation in this investigational study.

PART A (1) – VOLUNTEER AFFIDAVIT

Volunteer Subjects in Approved Department of the Army Research Studies

Volunteers under the provisions of AR 40-38 and AR 70-25 are authorized necessary medical care for injury or disease which is the **proximate** result of their participation in such studies.

I, ______________________________, SSN ______________,

Having full capacity to consent and having attained my ______________ birthday, do hereby volunteer/give consent as legal

Representative for ______________________________ to participate in ______________

Determinants of Stress Fracture and Bone Mass in Elite Military Cadets

(Research Study)

under the direction of Felicia Cosman, M.D.; Jeri Nieves, Ph.D.; LTC John Uhorchak, M.D.

conducted at: U.S. Military Academy, West Point, NY.

(Name of Institution)

The implications of my voluntary participation/consent as legal representative; duration and purpose of the research study; the methods and **means by** which it is to be conducted; and the inconveniences and hazards that may reasonably be expected have been explained to me by

Felicia Cosman, M.D.; Jeri Nieves, Ph.D.; LTC John Uhorchak, M.D., or Jamie Ruffing, M.P.H.

I have been given an opportunity to ask questions concerning this investigational study. Any such questions were answered to my full and **complete** satisfaction. Should any further questions arise concerning my rights/the rights of the person I represent on study-related injury, I **may contact**:

Felcia Cosman, M.D. or Jeri Nieves, Ph.D. at 914-947-786-4494;
LTC John Uhorchak, M.D. at 914-938-4733; or Jamie Ruffing, M.P.H. at 973-724-6635

at Helen Hayes Hospital, West Haverstraw, NY or Keller Army Hospital, West Point, NY

(Name, Address and Phone Number of Hospital (Include Area Code))

I **understand** that I may at any time during the course of this study revoke my consent and withdraw/have the person I represent withdrawn **from the** study without further penalty or loss of benefits; however, I/the person I represent may be required (military volunteer) or requested *(civilian volunteer)* to undergo certain examination if, in the opinion of the attending physician, such examinations are necessary for my/the **person** I represent's health and well-being. My/the person I represent's refusal to participate will involve no penalty or loss of benefits to which **I am/the** person I represent is otherwise entitled.

PART A (2) – ASSENT VOLUNTEER AFFIDAVIT *(MINOR CHILD)*

I, ______________________________, SSN ______________ having full

capacity to assent and having attained my ______________ birthday, do hereby volunteer for ______________

______________________________ to participate in ______________

(Research Study)

under direction of ______________________________

conducted at ______________________________.

(Name of Institution)

(Continue on Reverse)

PART A (2) – ASSENT VOLUNTEER AFFIDAVIT *(MINOR CHILD) (Cont'd.)*

The implications of my voluntary participation; the nature, duration and purpose of the research study; the methods and means by which it is to be conducted; and the inconveniences and hazards that may reasonably be expected have been explained to me by

____

I have been given an opportunity to ask questions concerning this investigational study. Any such questions were answered to my full and complete satisfaction. Should any further questions arise concerning my rights I may contact

____

at ____

(Name, Address, and Phone Number of Hospital (Include Area Code))

I understand that I may at any time during the course of this study revoke my assent and withdraw from the study without further penalty or loss of benefits; however, I may be requested to undergo certain examination if, in the opinion of the attending physician, such examinations are necessary for my health and well-being. My refusal to participate will involve no penalty or loss of benefits to which I am otherwise entitled.

____

PART B – TO BE COMPLETED BY INVESTIGATOR

INSTRUCTIONS FOR ELEMENTS OF INFORMED CONSENT: *(Provide a detailed explanation in accordance with Appendix C, AR 40-38 or AR 70-25.)*

Bone breaks with little trauma are extremely common in the US and throughout the world, affecting both women and men. Stress fractures in young adults may also be a manifestation of early osteoporosis, although some of the precipitating factors, such as level of trauma may distinguish these fractures from typical osteoporotic fractures in older adults. Clearly, limiting the risk of stress fracture is of benefit to the training of military cadets and is important in any occupation where repetitive lower extremity stresses are prominent. Furthermore, identifying factors which may be responsible for improving peak bone mass could perhaps help limit both the incidence of stress fracture, as well as the loss of bone mass which would have impact on the ultimate incidence of osteoporotic fracture. We hypothesize that stress fractures are common in elite cadets and relate to repetitive stresses occurring during intensive physical training. We anticipate that bone mass will be a major determinant of stress fracture risk. The determinants of bone mass in this population will be calcium intake, physical activity and abnormal hormone levels. Additional factors, which are independent of bone mass, such as bone turnover and bone geometry will also be determinants of stress fracture risk. Endocrine dysfunction, which will be common during the most intensive physical training, may be reflected by a change in bone turnover and deterioration of bone structure, which may also predict stress fracture risk, and will also have an ultimate effect to decrease bone mass.

You are being asked to participate in a clinical research study investigating the predictors of stress fracture and factors associated with the achievement of optimal peak bone mass. Your participation, which is voluntary, will last for the entire 4 years at the academy. Most of the information requested will be obtained through confidential questionnaire. Measurements of your bone mass and samples of blood will also be collected.

I do ☐ do not ☐ *(check one & initial)* consent to the inclusion of this form in my outpatient medical treatment record

SIGNATURE OF VOLUNTEER	DATE	SIGNATURE OF LEGAL GUARDIAN *(If volunteer is a minor)*	
PERMANENT ADDRESS OF VOLUNTEER	TYPED NAME OF WITNESS		
	SIGNATURE OF WITNESS		DATE

REVERSE OF DA FORM 5303-R, MAY 89

APPENDIX A

Project Title: Determinants of Stress Fracture and Bone Mass in Elite Military Cadets

Principal Investigator:	Felicia Cosman, MD
Co-Principal Investigator:	Jeri Nieves, Ph.D
Associate Investigators:	LTC John Uhorchak et al.

INFORMED CONSENT DA FORM 5303-R, MAY 89 CONTINUED

In this study, we will be assessing the frequency with which you might suffer lower extremity pain and tenderness consistent with a stress fracture and what activity you were performing at that time. We will be comparing cadets who have stress fractures with those who do not have stress fractures to see if a bone mass measurement of the tibia (lower leg) is predictive of the likelihood of having a stress fracture. Also, we will compare certain dimensions of the tibia bone (such as width of the bone) to see if this might affect the risk of stress fracture. Finally, we will look at certain variables in the blood which reflect the speed at which bone is repairing itself (a normal renewal process which occurs throughout life) and certain genes to see if these can predict the likelihood of having a stress fracture. Another aspect of this study is to determine the factors which help adults achieve a higher peak bone mass. The factors we will be looking at include diet, physical activity (including recreational and sports activities), bone turnover variables in your blood, and hormone factors, including menstrual function and hormone levels (in women) and hormone levels (in men).

As a participant in this study, you will be asked questions monthly via a password protected hot link web site. Within the first few weeks of arrival at the academy, a measurement of the tibia to determine bone mass will be performed. This is a quick test by a machine called the peripheral quantitative computed tomography, that is associated with no health risks other than a small dose of radiation which will be described in the risks and benefits. Another test to measure your bone mass will be made of your heel, this will also take less than a minute. These tests of your tibia and heel will be repeated at the start of your second year. Blood will be collected during your first week at USMA and at the start of your second year. In addition, all females and a random sample of male volunteers will have dual x-ray absorptiometry of the spine and hip. This is another simple, non-invasive bone mass test which takes less than 10 minutes. If you are in this sample, you will have repeat spine, hip, tibia and heel measurements every year for four years. Therefore, the major safety concerns involve the minor risks associated with taking ~~blood samples (2 samples of approximately 4 tablespoons) over the course of 12 months for most individuals or 6 over the course of 4 years for a subset of individuals)~~ and low dose radiation exposure.

Single blood sample

Our goal is to try to identify the risk factors that lead to stress fractures and lower extremity pain, and to determine the factors associated with changes in bone mass during your stay at the United States Military Academy. The findings of this study can be used to establish a profile of individuals who are at increased risk and to begin to develop simple methods for preventing stress fractures, including possible dietary modifications or provision of estrogen as an oral contraceptive to women with endocrine dysfunction. Any information we learn may help to improve the bone health and prevent stress fractures in future cadets. Your participation will last during your four years at the Academy. We will be asking all cadets from the class of 2002 to participate (average class size is 950 men and 150 women), however, your participation in this study is entirely voluntary.

SUBJECTS INITIALS______

APPENDIX A

Project Title: Determinants of Stress Fracture and Bone Mass in Elite Military Cadets

Principal Investigator: Felicia Cosman, MD
Co-Principal Investigator: Jeri Nieves, Ph.D
Associate Investigators: LTC John Uhorchak et al.

INFORMED CONSENT DA FORM 5303-R, MAY 89 CONTINUED

CONFIDENTIALITY:

All subjects will be assigned a study identification number. Confidentiality and anonymity will be preserved. Reminders to complete all questionnaire information will be sent via a dedicated web site with a hotlink installed on the reminder message. This is a password protected website to ensure confidentiality of all information provided. In addition, there are two further methods used to protect the storage of this data. All information on study subjects is kept in locked file cabinets and in computer files that are password protected and available only to the research staff of Helen Hayes Hospital, representatives of the funding agency (Medical Research and Development Command) and any other regulatory agencies. Names and other identifying information are kept separate from the questionnaire data. Data are presented by group statistics, not individual names.

QUESTIONNAIRE INFORMATION:

Stress Fracture Survey and Evaluation:

All cadets will be asked to complete a questionnaire about lower extremity pain syndromes, including location of pain, intensity (scale of 1-5), radiation of pain, setting in which pain first began, what positions intensify pain and what movements improve pain, what medications have been taken for it if any, and what medical care has been sought if any (Appendix 1). Cadets will complete this questionnaire via a website specifically for data collection in this proposal on a monthly basis. Cadets will be reminded monthly to complete this via E-Mail. All questionnaire responses will be password protected, in order to maintain confidentiality, and tracked by social security number. These questionnaires will be completed during regular E-MAIL maintenance periods and, in combination with the physical activity survey (below) should take less than 1 minute to complete each month. For any cadets who have sought medical attention, medical records and copies of diagnostic procedures will be obtained. Stress fractures will be diagnosed by LTC Uhorchak or his colleagues, with x-rays or special scans of the foot or leg as they deem appropriate.

Physical Activity Survey:

The cadets will complete a physical activity questionnaire each month. This will assess the activities that each cadet is involved in particular the extracurricular activities (appendix 1). An exercise physiologist (Investigator Dr Merle Myerson) will work with Maj Derrick in order to quantify what the caloric expenditure and the impact on the skeleton are for each activity that all cadets participate in as well as for the extracurricular activities. Completion of this survey as well as the stress fracture survey (above) should take less than 1 minute to complete each month.

Diet Survey:

Every six months the cadets will take a food frequency questionnaire, in order to evaluate the dietary intake of calcium, protein, caffeine and salt. This will also be taken via E-MAIL (Appendix 4) and should require less than 3 minutes to complete.

SUBJECTS INITIALS______

APPENDIX A

Project Title: Determinants of Stress Fracture and Bone Mass in Elite Military Cadets
Principal Investigator: Felicia Cosman, MD
Co-Principal Investigator: Jeri Nieves, Ph.D
Associate Investigators: LTC John Uhorchak et al.

INFORMED CONSENT DA FORM 5303-R, MAY 89 CONTINUED

Menstrual Function Evaluation:
All female cadets will have menstrual function assessed each month by a questionnaire accessed through E-MAIL during regular E-MAIL maintenance periods (Appendix 3). Completion of this survey requires less than 1 minute each month.

BLOOD COLLECTION:
Blood sample collection will be performed within the first few days of arrival at West Point. Thirty blood sample collectors will be recruited for assistance on this day in order to collect all samples in a timely fashion. Blood will be centrifuged and stored at -70 degrees until analysis. Variables of bone turnover and endocrine function will be assessed. Blood samples will also be analyzed for genetic variation in the genes which may be related to bone health.

PERIPHERAL QUANTITATIVE COMPUTED TOMOGRAPHY (pQCT) DETERMINATION:
You will have a pQCT measurement of the tibia (your lower leg) at the time of your entry to the military academy during the first 3 weeks of cadet basic training. This will provide a measurement of bone mass, structure and bone strength. This will be arranged during your PT (physical training) test when you will already be in shorts. This test will be repeated in all cadets at the beginning of year two. In a sub-group of male volunteers and all female volunteers, measurements will also be performed at year 3 & 4. This test has a radiation exposure of 14 mrem. Therefore you will be exposed to 28 mrems in two years. If you are in the subset of cadets you will be exposed to 56 mrems in 4 years. This can be compared to the average background radiation dose of 300 mrems that everyone is exposed to each year.

PERIPHERAL DUAL X-RAY ABSORPTIOMETRY:
You will have a peripheral dual x-ray absorptiometry measurement of the heel at the same time as the pQCT measurement, during the first 3 weeks of cadet basic training. This will be arranged during your PT (physical training) test when you would already be in shorts. This measurement will be repeated in all cadets during the beginning of their second year. This measurement takes less than a minute to perform. Measurements will also be performed in year 3 and 4 in a subgroup of cadets who are also undergoing dual x-ray spine and hip bone mass measurements (see below). The radiation dose for this test is less than 4 mrems each time you have the test.

DUAL X-RAY ABSORPTIOMETRY:
All female cadets (n=150) and a random sample of 150 male cadets will also be asked to have bone density scans of the lumbar spine and hip. This measurement will be made using the Lunar DPX-IQ bone densitometer mounted in a van. This will allow us to bring the measurement to a site which is convenient to you. Initial measurements will be at the range during basic cadet training. Measurements will be performed yearly for the next 3 years in this -subgroup of participants. The radiation dose for this test is less than 6 mrem for both the spine and hip measurement each year.

SUBJECTS INITIALS______

APPENDIX A

Project Title: Determinants of Stress Fracture and Bone Mass in Elite Military Cadets
Principal Investigator: Felicia Cosman, MD
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Associate Investigators: LTC John Uhorchak et al

INFORMED CONSENT DA FORM 5303-R, MAY 89 CONTINUED

RISKS AND BENEFITS:

There is exposure to very low levels of radiation from the bone density measurement. Total radiation exposure will be 36 mrem for the entire study for all cadets for the leg and heel bone density scans. For a subset of male cadets and all female cadets, there will be a total radiation dosage of 96 mrem for the entire study (4 years) using the techniques described above. This maximal amount of total radiation over the 4 years is still far less than the background radiation you normally receive per year by living in the United States (300 mrem per year or 1200 mrem over 4 years). Thus the risk to you from this additional radiation exposure is too small to have a measurable risk. The radiation dosage for each procedure is described below.

Table 1: Total Radiation Exposure Each Year for all cadets (2 years total)

Measurement:	Radiation Dose	Percent of background	% health care exposure
Peripheral pQCT of leg	14		
Dual x-ray of heel	4		
Total per year	18	6%	0.36%
Total for entire study	36	6%	0.36%

Table 2: Total Radiation Exposure Each Year for all female cadets and a subset of males (4 years total)

Measurement:	Radiation Dose	Percent of background	% health care exposure
Peripheral pQCT of leg	14		
Dual x-ray of heel	4		
Dual x-ray of spine/hip	6		
Total per year	24	8%	0.48%
Total for entire study	96	8%	0.48%

Women who could be pregnant must notify the investigator and/or radiologic technologist who performs this test and should not undergo the test under any circumstances. Female cadets who are sexually active should not participate in this research study if there is a potential of pregnancy. If you wish to participate in this research, but are uncertain about your current condition, please obtain clearance by consultation with the health clinic (914-938-3003) who will perform a serum pregnancy test.

The risks of drawing two tubes of blood are minimal in healthy individuals (i.e. there may be redness, bruising or swelling at the site where blood is taken), and no other complications are expected. The primary benefit of the study is that if risk factors for low bone mass and/or stress fracture can be identified, methods of prevention can be suggested to both cadet populations and the population as a whole. It also may be of some benefit for a person to know his or her bone density. The benefits of this study, in terms of knowledge gleaned, clearly outweighs the minimal risks associated with its completion.

SUBJECTS RIGHTS:

Your participation in this study is voluntary and your refusal to participate will involve no penalty or loss of benefit to which you are otherwise entitled. The extent of medical care provided to you, should it become necessary, is limited, and will be within the scope authorized for DOD health care beneficiaries. Necessary medical care does not include domiciliary care (nursing home care). There will be no cost to you for any

SUBJECTS INITIALS______

of the medical tests performed as part of this study. You will not receive any compensation (payment) for injury. You also understand that this is not a waiver or release of your legal rights. Should you have any questions, you should discuss this issue throughly with one of the investigators before you enroll in this study.

All data and medical information obtained about you as an individual will be considered privileged and held in confidence; you will not be identified in any presentation of results. Complete confidentiality cannot be promised, particularly to subjects who are military personnel, because information bearing on your health may be required to be reported to appropriate medical or command authorities. Also, governmental and military agencies have the right to review the research data.

Any new findings that develop during the course of this study that could affect your willingness to continue participation will be explained to you. You have the right to discontinue your participation in this study at any time, and if you do so, you will not be penalized.

If you would like information about the study or your rights as a participant in this study, you can contact Dr. Felicia Cosman or Dr. Robert Lindsay at 914-786-4494 or Dr. Jeri Nieves at 914-786-4833. One of the investigators will explain any results to you at your request. If at any time during the course of this study you feel you are being mistreated or are unhappy with the study, you may contact the Clinical Patient Advocate at: 914-938-5874. We the investigators would like to thank you for your cooperation in this study.

PATIENTS STATEMENT

I voluntarily consent to participate in this study.

I have read and understand this statement of informed consent and the risks described.

I understand that I will receive a copy of this consent form.

I understand that I may withdraw my consent at any time.

_________________________ _________________

Volunteers Signature Dated

I have witnessed that the information in this Patient Consent Form was adequately explained to the patient.

_________________________ _________________

Witness's Signature Dated

I attest that I have fully and appropriately informed the patient of the nature of the above study and have offered to answer any questions he or she may have.

_________________________ _________________

Investigators Signature Dated

revised 6/25/98

Menstrual Function Survey

Did you have a normal period this month?

- yes
- no

What date did your period start this month?

mm/dd/yyyy (e.g. 08/02/1998)

How many days did you have a menstrual flow?

days

Please check any of the following that you may have experienced in the 2 weeks before your period began:

- abdominal pain or pelvic discomfort
- cramping
- vaginal spotting

Please check any premenstrual symptoms you experienced a few days to a week before your period began:

- mood swings
- bloating
- weight gain

How much emotional stress do you feel you are under?

1	2	3	4	5
none		moderate		a great deal

Are you currently taking the Birth Control Pill?

- yes
- no

Page last modified: 6 July 1998

APPENDIX C

Determinants of Stress Fracture
and Bone Mass
in Elite Military Cadets

Baseline Survey

Instructions: This survey is part of the "Determinants of Stress Fractures and Bone Mass in Elite Military Cadets Study." It will take you approximately 5 minutes to complete. It is important that you answer honestly and openly. It could affect the findings of the study which can prevent injuries/stress fractures. This information will be held in the strictest confidence.

Name ______________________ Company ____________ SSN ____________

Exercise History

1. During the past 2 years, what was your exercise pattern?
   a. 1 to 3 hours per week
   b. 4 to 6 hours per week
   c 7 to 10 hours per week
   d. 11 or more hours per week

Nutritional Information

2. During the past 2 years, how many caffeine containing drinks did you have per <u>day</u> on average?
   a. None
   b. 1 to 3
   c. More than 3

3. During the past 2 years. how many glasses of milk did you have per <u>day</u> on average?
   a. None
   b. <1
   c. 1 to 2
   d. 3 or more

4. During the past 2 years, how many cups of yogurt did you have per <u>week</u> on average?
   a. None
   b. 1 to 3
   c. 4 to 6
   d. 7 or more

5. During the past 2 years, how many servings of cheese did you have per <u>week</u> on average (including pizza, macaroni and cheese, etc.)
   a None
   b. 1 to 3
   c. 4 to 6
   d. 7 or more

6. During the past 2 years, how many servings of broccoli, mustard greens, collards, or kale did you have per <u>week</u> on average?
   a. None
   b. 1 to 3
   c. 4 to 6
   d. 7 or more

7. During the past 2 years have you taken vitamins or diet supplement drinks/powders?
   a. Yes (what is the name of the supplement____________________)
   b. No

8. Do you salt your food?
   a. Yes
   b. No

Alcohol Consumption

9. How would you characterize your alcohol consumption during the last year?
   a. less than 1 time a month
   b. 1 to 3 times a month
   c. 1 to 2 times a week
   d. 3 to 5 times a week
   e. daily

Tobacco Usage

10. Do you smoke?
    a. Yes
    b. No

    If yes, for how long have you been smoking? __________ Number of packs per day? __________

11. Do you use chewing tobacco?
    a. Yes
    b. No

    If yes, for how long have you been chewing tobacco? __________

12. Do you use "dip"?
    a. Yes
    b. No

    If yes, for how long have you been using "dip"? __________

Medical History

13. Have you ever had a bone break (fracture)?
    a. Yes where__________________
    b. No

14. Has anyone in your family had a fracture as an adult?

	Yes	No
Mother		
Father		
Grandparents		
Aunts/Uncles		

Women's Section

15. At what age were you when you started menstruating?____________

14. How many times in the last year did you have a menstrual cycle?
    a. 0 to 3 times
    b. 4 to 6 times
    c. 7 to 9 times
    d. 10 to 12 times

15. Are you currently taking the birth control pill (BCP)?
    a. Yes
    b. No

    If yes, for how long have you been taking the BCP? __________

16. If you took the BCP in the past, for how long were you taking it? __________

APPENDIX D

Food Frequency Survey

Foods List	Medium Serving Size	Serving Size			Frequency			
		S	M	L	No. of Servings	per Day	per Week	per Month
Dairy Products								
cottage cheese	½ cup							
cheese	2 oz 2 slices							
yogurt	1 cup							
tofu	2 oz							
Breakfast Foods								
cereal with milk	1 medium bowl							
Mixed Dishes/Lunch Items								
cheese dishes, such as macaroni and cheese	1 cup							
pizza, lasagna	2 slices							
Sweets								
ice cream or frozen yogurt	1 scoop ½ cup							
Vegetables								
mustard greens, turnip greens, or collards	½ cup							
beans, such as pinto, kidney, baked, or black-eyed peas	¾ cup							
broccoli or kale	½ cup							
Beverages								
glass of milk	8 oz							
coffee or tea (caffeinated)	1 cup							
cola product (caffeinated, diet or regular)	12 oz.							

To how many meals per day do you add salt?

0 1 2 3 meals per day

Do you take any vitamin supplements?

yes no

Do you take a calcium supplement or is calcium contained in your vitamin supplement?

yes no

APPENDIX E

The effects of gender on bone mass and biomechanical competency of the axial and peripheral skeleton in adolescent elite military cadets.

C. Formica, J. Nieves, V. Shen, J. Ruffing, R. Lindsay, F. Cosman.

Clinical Research and Regional Bone Centers, Helen Hayes Hospital, West Haverstraw, NY, USA

Introduction:
Stress fractures in military cadets are far more common in females than males (Deuster, Moore and Jones, Military Medicine :1997). Gender differences in stress fracture, and possibly adult fracture have been attributed to gender differences body size, skeletal size, skeletal geometry or true differences in bone density. A population of adolescent boys (n=36) and girls (n=36), mean age 18 years matched for height and weight were recruited from the United States Military Academy, West Point, NY. In this population we determined the gender-related differences in bone size, mass, geometry and biomechanical competence.

Methods:
Bone size (area), mass (g), bone density (g/cm2) of the lumbar spine and proximal femur were measured by dual x-ray absorptiometry using the (Lunar DPX-IQ). In addition, geometric parameters and strength indices were derived using the method described by Yoshikawa (JBMR, 1994). Distal tibia bone density (mg/cm3), cortical thickness and strength indices were determined by pQCT (Stratec XCT-2000).

Results:
At the lumbar spine, no differences were observed for vertebral bone mass, or area, with a trend towards greater areal density ($p < 0.06$) in the boys compared to girls. Despite similar vertebral height, the boys had greater vertebral width compared to the girls (4.50 ± 0.05 vs. 4.31 ± 0.05 cm, $p < 0.01$). No differences were observed for femoral neck areal density and total femur areal density. By contrast, boys had greater bone mass and bone area at both the femoral neck (6.2 ± 0.1 vs. 5.7 ± 0.1 g, and, 4.9 ± 0.1 vs. 4.7 ± 0.1 cm², respectively, $p < 0.02$ for both) and total femur (43.6 ± 1.0 vs. 38.0 ± 0.9 g, and, 34.4 ± 0.4 vs. 32.0 ± 0.4 cm², respectively, $p < 0.01$ for both) compared to girls. At both the trochanteric region and the femoral shaft, boys had greater areal density, mass and area ($p<0.01$ and $p<0.05$, respectively). For geometric variables of the hip, boys had greater femoral neck diameter (34.3 ± 0.4 vs. 33.0 ± 0.4 mm, $p<0.02$), center of the femoral head to the neck axis-shaft intersection length (53.8 ± 0.8 vs. 51.1 ± 0.8 mm, $p<0.02$), center of femoral neck mass to the superior neck margin length (17.0 ± 0.3 vs. 16.1 ± 0.2 mm, $p < 0.01$) and femoral neck CSA (232.9 ± 4.9 vs. 213.7 ± 4.9 mm², $p<0.01$), compared to girls. These geometric parameters resulted in 17% greater CSMI ($p<0.01$), 13% higher Safety Factor ($p<0.02$) and 10% higher Fall Index ($p<0.03$) in boys. A subset of boys and girls were matched not only for height and weight but also for total hip bone area (males 33.0 vs females 33.0). Males still had a significantly greater bone mass and bone mineral density as compared to females (43.7 ± 1.8 vs. 38.6 ± 1.6 g, $p < 0.05$ and 1.32 ±0.04 vs 1.17 ±0.03, $p<0.01$ respectively).

Tibia length between boys and girls was not different. However, at the distal tibia, boys had greater tibial bone mass (333.3 ± 6.7 vs. 299.2 ± 6.2 mg/mm, $p < 0.01$), volumetric density (851.5 ± 14.2 vs.

804.9 ± 10.9 mg/cm³, $p<0.02$) and cortical area (270.7 ± 5.7 vs. 238.6 ± 5.0 mm², $p<0.01$). Cortical thickness was also greater in the boys (5.0 ± 0.1 vs. 4.4 ± 0.1 mm, $p<0.01$). This was the result of greater periosteal circumference and smaller endosteal circumference in the boys compared to the girls. These structural differences resulted in 13% greater axial moment of inertia, 11% greater moment of resistance, and 13% greater polar moment of inertia, in boys compared to girls.

Discussion:
Despite comparable body size, boys and girls still have differences in skeletal size. These differences relate to differences in the width and possibly depth of bone, but not length of the long bones or height of vertebrae. In the spine despite comparable height and bone mass; a significantly greater vertebral width in males may infer greater biomechanical competence in males. It is unlikely that bone volume differences would totally explain the BMD difference, in part based on tibial analysis demonstrating greater cortical thickness and because after matching for total hip area substantial gender differences were still found. This study was limited by the potential for selection bias in this population of smaller men and larger women. Furthermore, gender differences in acquisition of peak bone mass might influence the results. Lastly models for structure and geometric parameters are limited by the 2-dimensional acquisition plane of dual x-ray absorptiometry. However, we conclude that gender differences in bone density are skeletal site dependent and that these differences in bone size and mass confer greater skeletal integrity in boys, which may contribute to the lower gender-specific stress fracture incidence, and possibly adult fracture incidence observed in adults.

Acknowledgments: This study was support from a grant from the USDMARDC

APPENDIX E

I Osteoporosis - Epidemiology
Cosman, Felicia

ASBMR 21st Annual Meeting
Official Electronic Abstract Submission

Presenting Author: Felicia Cosman
Address: Regional Bone Center, Helen Hayes Hospital, RT 9W, West Haverstraw, NY 10993
Phone: 914 786-4494 **Fax:** 914 786-4848 **E-mail:** jruffing@pica.army.mil

Filename: 533680
Abstract Categories: I Osteoporosis - Epidemiology, G Osteoporosis - Pathophysiology
Prefer poster presentation? No
Awards:
Keywords: stress fracture, bone density, cortical thickness
Special Needs/Scheduling Conflicts:
Payment Type: Electronic

Predictors of Stress Fractures in Elite Military Cadets

Felicia Cosman, MD[1], Jamie A. Ruffing, MPH[1], Jeri W. Nieves, PhD[1], Carmelo A. Formica, PhD[1], Robert Lindsay, MD, PhD[1]. Clinical Research and Regional Bone Center, Helen Hayes Hospital, West Haverstraw, NY, USA.

We idenitified a cohort of 891 elite cadets entering the United States Military Academy Class of 2002 (753 males and 138 females) to determine stress fracture predictors. Cadets completed a baseline historical survey, had an assessment of running ability upon entering and a BMD measurement of the heel by peripheral DXA. 768 cadets also had PQCT measurements of the tibia (646 males and 122 females). All cadets were assessed for the occurrence of stress fracture during the first six months at the academy. Stress fractures were identified as pain, swelling and tenderness of the lower extremities and confirmed by x-ray or radionuclide scan. There were 51 stress fractures in 37 cadets . The majority of the fractures were metatarsal (40), followed by tibia (8), fibula (2) and femur (1). Incidence over 6 months was 18% in females and 3.5% in males ($p<.05$). Therefore, female and male cadets were analyzed separately for other predictive factors. No historical factors, including previous history of fracture, family history of fracture, menstrual regularity, calcium or caffeine intake, or exercise during the preceding year related to stress fracture occurrence. Run score was lower in both female and male cadets who fractured but differences were not significant ($p=.014$ females , $p=.26$ males). BMI was not related to stress fracture occurrence. Mean BMD of the heel was nearly one standard deviation above average for both females and males. Nevertheless, in women, heel BMD was related to stress fractures (mean= .558±.025 g/cm^2 in fracture cases and .595 ±.009 g/cm2 in non fracture cases ;$p=.17$). Moreover, mean spinal and hip BMD determinants were lower at all sites in women with fractures compared to women without (all $p<.08$). In men , however, the difference in the heel BMD was minimal in cadets with fractures (.708 ±.034 g/cm^2) versus no fractures (.718 ±.005g/cm2). In contrast, in men, tibia mean total bone content in stress fracture cases was 331.8±10.6mg/mm versus 359.1 ±1.86 mg/mm in non-fracture cases ($p=.01$). Furthermore, cortical thickness in males who had fractures was lower than in those who did not have a fracture (4.74 ±.02mm vs 4.97 ±.12 mm,$p=.14$). These tibial dimensions did not predict stress fracture occurrence in females. We conclude that stress fracture occurrence is predicted by DXA at all sites in females but not in males, where tibial dimensions appear far more important. The etiology of stress fracture occurrence in females vs males appears to differ.

The essential findings of this abstract HAVE NOT been submitted for publication prior to May 5, 1999.

Jamie Ruffing for

Signature of sponsor: Felicia Cosman

APPENDIX E

SOCIETY FOR EPIDEMIOLOGIC RESEARCH
ANNUAL MEETING ABSTRACT FORM:
JUNE 10-12, 1999, BALTIMORE, MARYLAND

Date: January 29, 1999 Signature: Jeri W Nieves
Phone: (914) 786 – 4833 Degree: Ph.D.

Are you a member of SER? Yes No
Presenter's Name: Jamie A Ruffing MPH
Address: Clinical Research Center
Helen Hayes Hospital and Columbia University
New York, New York 10032

Study Category: Other/ Bone Health

Relationship Between Body Mass Index, Fitness Levels and Bone Mineral Density in Elite Military Cadets.
J Ruffing, J Nieves, CA Formica, R Lindsay and F Cosman. Clinical Research Center, Helen Hayes Hospital and Columbia University, NY, NY 10032

The interrelationships between bone mineral density (BMD), body mass index (BMI) and measures of fitness are unknown. The entry fitness scores (PT) from the United States Army's standardized fitness test were calculated as a sum of push-ups, sit-ups and time on a 2-mile run (RS) in cadets upon entry to the United States Military Academy at West Point. BMD of the left calcaneus was measured by dual x-ray absorptiometry (Lunar PIXI). 848 cadets (717 males; 131 females) with a mean age of 18.8 years (range 16-23) were assessed. The mean and standard deviation (SD) values for males and females respectively, were as follows BMI (24.7±3.4 and 23.1±2.3 kg/m2 $p<0.0001$); BMD (0.72±0.14 and 0.59 ±0.09 g/cm2; $p<0.0001$) and PT score (214±33.8. and 206±42; $p<0.03$). For both males and females mean BMD values were approximately one SD above mean young normal. Fitness scores in elite cadets were more than one SD above scores in enlisted military personnel. Five percent of the population had BMI under 20, 57 % had normal BMI (20 –25) and 38% had a BMI in excess of 25 (considered overweight). BMD was correlated with BMI ($r=0.46$ to 0.48; $p<0.001$) and RS / PT measures were inversely correlated with BMI ($r=-0.25$ to -0.45; $p<0.001$) in both males and females. BMD was also inversely correlated with RS/PT in males ($r=-0.2$; $p<0.001$) but not in females. The number of menstrual periods was inversely related to BMD with those women having less than 9 cycles each year having significantly lower BMD (0.554±0.016 vs. 0.593±0.009 g/cm^2 ;$p<0.05$) then those with normal cycles greater 10 a year. Menstrual dysfunction seen in elite female athletes may ameliorate the positive effects associated with high physical fitness on BMD.

All abstracts must be received by regular or express mail (FAX copies not acceptable) **in final form no later than February 1, 1999.** *Please see instructions on the back of this form.*

Send by mail **(FAX copies not accepted)** to:
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